ON NON-NITROGENISED FOOD

IN A

PHYSIOLOGICAL POINT OF VIEW

BY

MESSRS SELLER AND STEPHENS

AUTHORS OF 'PHYSIOLOGY AT THE FARM'

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EDINBURGH AND LONDON
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MUCH confusion has already arisen, and more is likely to arise, from mixing up, without sufficient discrimination, ideas derived from physiology in the nutrition of animals with ideas belonging specially to the fattening of farm stock for the market. To read some treatises one might suppose that the great doctrine—which has rested now for more than forty years on the authority of the exact experiments of Magendie, to the effect that non-nitrogenised food cannot support the life of animals beyond a short period—had already passed away, like so many of the transitory fashions of this busy world. What a lesson of truth in physiology to the young agriculturist thirsting after new knowledge is, for example, the following sentiment from a recent periodical: "The nitrogenous portion of food, though highly valuable as enriching the manure, is so far from a test of nutritive properties that Dr Voelcker places it below digestible woody fibre." *

It would be out of place here to digress at length into the evidence of the truth of Magendie's views. His experi-

* 'The Field,' April 27, 1867.

ments are accessible, in an English form, in the fourth edition of his 'Physiology,' translated by Milligan. The confirmatory experiments of Chossat are in the 'Gazette Medicale de Paris,' Oct. 19, 1843; those of Letellier in the 'Annales de Chimie et de Physique,' 1844; and the experiments of Tiedemann and Gmelin to the same effect are in a French translation of their work 'Recherches sur la Digestion;' while the extended experiments of Savory are in the 'Lancet' of April 1863. These last experiments further show that, while animals speedily die when confined to a non-nitrogenised diet, they may live long when fed exclusively on nitrogenised aliment.

Notwithstanding the paramount importance of the distinction of food into the nitrogenised and the non-nitrogenised, it is still requisite to retain the older well-known division into albuminous, saccharine, and oleaginous—the first corresponding to the nitrogenised, and the two others to non-nitrogenised aliment.

These three forms of aliment are all transformations of mineral matter; but they do not take their origin therefrom within the animal body, but only in the vegetable kingdom. The line at which organic nature intercommunicates with the mineral world is in the region occupied by the vegetable cell in or adjacent to the leaves; the organic membrane of that cell, and the protoplasma or primordial rudiment of organic substance which the cell contains, are the agents under the influence of solar light in the continued metamorphosis of water, carbonic acid, ammonia, and a little saline matter into the materials of living structure. It may be, however, that the protoplasma is compound in the vegetable cell, or different in different cells; and that this protoplasma being truly a representative in composition of several principles, such as proteine, sugar, or oil, does not so much create a metamorphosis, as simple

growth in quantity, by the accretion of new matter. Be this, however, as it may, it is easy to understand, for example, that a saccharine protoplasma can produce all the varieties of organised products, by the addition or subtraction of water, carbonic acid, and ammonia, along with what is needful of saline matter. But not to dwell on points like these, still of an abstruse character, let us see how modern physiology views this subject according to its most recent determinations. The following passage is from a standard work, the last edition of Carpenter's 'Physiology':—

"That none of the non-azotised substances can be made capable, by metamorphosis or combination within the animal body, of taking the place of the azotised substances, as 'histogenetic' or 'plastic' compounds, may now be regarded as one of the most certain facts in physiology; the concurrent evidence of experiment and observation leading to the conclusion that in plants alone can any production of azotised compounds take place, and that animals are in consequence directly or indirectly dependent upon the vegetable kingdom for their means of subsistence. If animals be fed exclusively upon saccharine or oleaginous substances of any kind or in any combination whatever, they speedily perish with symptoms of inanition; and the only assistance which such food affords in the prolongation of life is derived from its calorific power." *

To nitrogenised and non-nitrogenised aliment respectively the most appropriate names for the present are flesh-formers and fat-producers, the latter instead of heat-makers, since it cannot be doubted that both are capable of originating animal temperature.

With the same disregard to the distinction in the physiology of nutrition between the flesh-formers and the fat-

* 'Principles of Human Physiology,' p. 36.

producers, the writer from whom our quotation above was made goes on to say, in speaking of a late lecture of Dr Voelcker's: "Not only is it excellent for its facts as to the relative manurial value of different foods, but also for clear and sound information as to the feeding value of the different ingredients. Experiment and observation have demonstrated the error of valuing foods in proportion to the amount of nitrogenous material they contain; and we are surprised to find that, notwithstanding the conclusive and exhaustive experiments of Messrs Lawes and Gilbert, despite the investigations of Dr Voelcker and others, and in the face of the experience of practical men, Messrs Seller and Stephens, in their new work, 'Physiology at the Farm,' adhere to a position which is clearly untenable. Nay, they go so far as to give formulæ for the treatment of farm stock, the different foods being selected, and the quantities arranged solely according to their richness in nitrogenous materials."*

It would not have been a great concession on the part of the writer to have remembered that the work published by Messrs Seller and Stephens is not a special work on the feeding of farm stock for the shambles, or on any other particular department of agricultural pursuit, but a work embracing principles derived from the established physiology of the animal kingdom, suggestive of lessons by which to try the current, but too often transitory, fashions of the day in the rearing and feeding of the animals of the farm, whether destined for labour or for slaughter. But it so happens that in the case to which this writer refers there is no need for the apologetic. The very formulæ which he censures Messrs Seller and Stephens for giving in respect to the feeding of farm stock, are formulæ taken by them from Messrs Lawes and Gilbert, subjected to no other alteration but a resolution into flesh-formers and fat-producers by a slight

* 'The Field,' April 27, 1867.

merely arithmetical dissection. In short, this writer rushes on in his tilt against flesh-formers without discovering that the burst of eloquent invective directed against the new work of Messrs Seller and Stephens really falls on one of the most esteemed papers published somewhat recently by his deservedly-trusted idols, Messrs Lawes and Gilbert, who do not appear to fear recommending linseed-cake, chopped hay, and turnips as a good diet for a rapidly-fattening ox, not knowing that by so doing they are, in the opinion of this writer, "acting in defiance of their own conclusive and exhaustive experiments, despite of the investigations of Dr Voelcker and others, and in the face of the experience of practical men." *

The passage in 'Physiology at the Farm,'† just referred to as taken from Messrs Lawes and Gilbert, on fattening of oxen, is made up from their tables, and is not, therefore, to be found word for word in their paper; but the accuracy of its substance is sufficiently guaranteed, first by Table III., in which of five oxen averaging 1299 lb. weight, the increase is such, after two months, that the then average is 1467 lb.—the gain being at the rate of 20.6 lb. per week overhead, and the gain per 100 lb. of live weight per week 1.49 lb.; the food being oilcake, chopped clover-hay, and Swedish turnips, the average daily amount of which, as obtained from Table IX. of the same paper, is 7.6 lb. of oilcake, 12.5 lb. of chopped meadow-hay, and 44.0 lb. of Swedish turnips—the somewhat higher numbers given in the text of 'Physiology at the Farm' being the result of taking the round number 1400 lb., instead of the average weight—viz., 1467 lb., with a variation in the mode of calculation. ‡

* 'The Field,' April 27, 1867.

† 'Physiology at the Farm,' p. 551, 552.

‡ 'Journal of the Royal Agricultural Society of England,' vol. xxii. 1861, p. 205-209.

After having thus shown that this mode of feeding a fat ox was borrowed from Messrs Lawes and Gilbert, it would be presumption to add any commentary.

The passage from Dr Voelcker's lecture which this writer then cites, as exposing at once the error into which, as he thinks, Messrs Seller and Stephens have fallen, will be dealt with hereafter as one of the topics of the lecture with which the lecturer has confused the ideas of the less intelligent part of his audience.

This writer claims Dr Voelcker for his instructor; he thinks he is doing no more than following out the Doctor's views. We cannot but think him very far mistaken in this idea.

It seems impossible that this writer can have read the following passage in Dr Voelcker's lecture: "A third reason, which may be mentioned, for the superiority of the British over the Continental stockfeeder, lies in the fact that, whilst in many parts of France, Germany, and Holland, and indeed throughout the continent of Europe, animals are half-starved in their infancy, the British farmer supplies his young stock abundantly with cake and food which is usually called concentrated, or, to speak in chemical language, with nitrogenous food; nor does he cram young stock too much with chaff, innutritious grass, and similar bulky food. I should not like to say a word in disparagement of straw as food. Straw is a most valuable food in its proper place; and indeed, for fattening beasts which are abundantly supplied with oilcake, a certain amount of tender straw-chaff appears to be almost indispensable, if hay-chaff is not at command. Young stock, however, should not be supplied too abundantly with food which is so poor in nitrogenous matter, in fibre-producing substances, as straw is proved to be: and the English breeder of stock

seems to have learned this practical lesson from his own experience." *

This passage draws a broad line of demarcation between Dr Voelcker's sentiments and those which the writer before us would represent the Doctor to entertain. Dr Voelcker is, in short, a stanch supporter of those principles of the physiology of animal nutrition which this writer describes as rendered obsolete by the same chemist's investigations.

This lecture, indeed, by Dr Voelcker, now under consideration, cannot be regarded as couched in the terms of the physiology of animal nutrition, and would have required some special name to guard his hearers from regarding his propositions as general truths in that department. It is not even wholly a special discourse on the feeding of stock for the market, being, in the first part, limited to the feeding of stock when manure is no object; and this is manifestly the source of all the confusion it has created in the mind of the writer in the 'Field.' Now, surely in agricultural works the subject of feeding cattle without any purpose of obtaining manure, should have its rules carefully guarded from being confounded with the general rules of cattle-feeding on the farm. The rules in the lecture hardly extend to the whole of feeding—it is confined to the fattening of stock; the beef and mutton are left to shift for themselves, while all the solicitude is lavished on the fat. Whether it be a perfectly safe proceeding in these times of epizootic maladies to neglect the cultivation of the muscular flesh, in which the living strength most certainly lies, or to run the risk of starving the blood, which is as surely the source and fountain of animal vigour, is a question which cannot be too seriously pondered over. The risk of epidemics

* Lecture at the Royal Agricultural Society, in 'Supplement to Bell's Weekly Messenger,' April 15, 1867.

of the most serious character among bodies of men from any considerable diminution of nitrogenised food, has been but too well exemplified in recent times; and we cannot but consider it as a most dangerous innovation to place the nitrogenised food of animals beneath any form of non-nitrogenised food in essential importance, however much the relative quantities necessary may differ under particular circumstances. Nitrogen is always passing from the living body, even under the most perfect rest, and its place must be as constantly supplied. For the proof, let any one ask himself, What is urine? What but a nitrogenised fluid? What would urine be on any day of the year without urea?

When Dr Voelcker, without any limitation or qualification, says in his lecture, "The most valuable feeding material is ready-made fat and oil," it would have been well if he had made his less instructed readers aware that Magendie found each of two dogs, fed exclusively on pure olive-oil and water, to die on the thirty-sixth day, having apparently thriven on that diet only for fifteen days; and that another dog, fed on butter, had almost exactly the same fate.

It must be confessed, however, that our views of the physiology of nutrition in animals are losing much of their original simplicity, and acquiring an intricate controversial character, owing, in particular, to the aspect under which the subject has passed in the hands chiefly of chemical physiologists. Voelcker may be regarded as heading one party of these chemical physiologists, while the leader of another party of more determined controversialists, at least in this country, is Frankland.

To obtain a clear idea of what each of those chemists in particular inculcates must then be our first object, and our next to consider how far the view of each will bear comparison with the facts ascertained as to the function of nutrition in the animal world.

And it will be well to bear in mind, in the mean time, that the physiology of animal nutrition is but in a progressive state—that it has made great strides of advancement within a short period of years, but that it is only the larger outlines that can be regarded as exact, while much of the filling-up in detail still remains to be made. Again, that the great use of a work on the physiology of nutrition in the farm animals is to embody the chief things on the subject that are known, or thought to be known, in order that the experience, the observation, and the sagacity of practical agriculturists may be engaged to approve, contradict, or modify them in each particular case. In short, to compare small things with great, that the leading defect, as respects the physiology of nutrition in the farm animals, has been the want of a comprehensive work, such as the illustrious Haller, in the last century, left to human physiology in his 'Elementa Physiologiæ'—a work to employ the industry of after-times in detecting error, and in approximating the various acts of life nearer and nearer to the truth.

In a work embracing so many particulars as 'Physiology at the Farm,' the authors would have been blinded by overweening conceit to have anticipated attaining anything approaching to a perfect accuracy. All the success they could hope for was to gain credit for keeping free from the charge of negligence, and doing their utmost to select for their statements the best authorities within their reach. These two objects they trust they have accomplished. Most of the faults ascribed by critics to 'Physiology at the Farm' have taken their origin in a misunderstanding of what the physiology of animal nutrition really signifies, and a consequent misconception of what ought to be the plan and contents of such a book. To many of their critics, however, the authors owe their grateful thanks for the pains they have taken to point out the multiplied uses to

which the contents of the work can be applied in the pursuits of agriculture. They feel grateful, also, for the notice of mistakes, oversights, or doubtful statements, such as cannot but occur in a work of any great variety and extent.*

Some critics, more or less favourable in other respects, have blamed the large space devoted to the enumeration of dietetic plants in a botanical arrangement. The authors an-

* Nevertheless a reply may be allowed to one or two minor remarks that have been made. It is doubted by one critic that breeding in-and-in induces the diseases of hydatids and rot in sheep. To whatever extent the superior experience of the veterinary art in the present times may have confirmed that doubt by established practice I have not yet seen demonstrated. I know that fifty years ago it was the belief both of farmers and shepherds on the Borders (there were few veterinarians in those days), that the many cases of sturdy and rot in sheep, which carried off hundreds of them in the cold and wet seasons of 1816 and 1817, were occasioned by the delicacy of their constitutions, induced by being bred in-and-in. At that period scarcely a single flock of Leicesters on the Borders was free from the taint of overbreeding, whereas now, scarcely a single bred in-and-in sheep can be found there. We may therefore reasonably conclude that modern veterinary experience has little chance of seeing in sheep the bad effects of breeding in-and-in.

The same critic seems to ridicule the practice of feeding poultry only twice a-day in winter, while they are fed three times a-day in summer, when there is plenty of "scratch" for them. He seems to have forgotten that fowls are off their roost from five o'clock in the morning to seven o'clock in the evening in summer—that is, fourteen hours; whereas in winter they are out only from eight o'clock in the morning to three o'clock at most in the afternoon—that is, seven hours. Fowls always go to roost before sunset. If thus two feeds are given in winter in seven hours, in the same ratio four feeds should be given in fourteen hours in summer, and yet only three feeds are supplied; surely, then, sufficient time is provided in summer for "scratch." "Scratch," no doubt, affords poultry gravel, lime, and insect animal condiment, but these good things may be dearly bought at the expense of disintegration of the muscular fibres during a continued act of "scratching." The simple mode of feeding poultry suitable to the means of every farmer, and practised for many years, as taken from the 'Book of the Farm,' and referred to in the 'Physiology at the Farm,' although consisting of "platitudes" according to the critic's opinion, having produced turkeys at Christmas from 15 to 18 lb. each, and chickens and fowls at all seasons ready for the table, any one can see at a glance is a far more profitable system for the farmer than his giving his fowls liberty to "scratch" in the longest summer's day.—H. Stephens.

ticipated such an objection ; they foresaw that it could not fail to be made ; nevertheless they do not repent of having introduced this list of dietetic plants, and they think that, on reflection, their readers will come to think with them as to its utility. To have a list of all the plants known throughout the world to contain nutritive substance fit for the sustenance of the higher animals is of itself a great object attained. To have placed these in a catalogue under such heads as esculent fruits, esculent roots, esculent leaves, esculent stems, would have disarmed criticism. To place them as they have been placed in 'Physiology at the Farm,' in natural families, under a botanical arrangement, seems, on a superficial view, to occupy space with unnecessary names and titles. There is, however, a misunderstanding here. When a plant is referred to its proper natural family, and that family to its class, subclass, and the like, there is already, without any further statement, a large account given of that plant at the least expense of space. This advantage, in short, is the great benefit of method and arrangement, on which so much pains is bestowed, not merely in botany, but in all the branches of natural history.

Of the 140 pages complained of as forming the weak part of the book, because devoted to plants fit to nourish the higher animals, 105 pages turn on plants that could not have been omitted in the most meagre attempt at the physiology of nutrition, consisting of such groups as the cabbage order, the flax order, the bean order, the artificial grasses, the umbelliferous or carrot and parsnip order, the compositæ or yarrow order, the goose-foot or beet order, the polygonaceæ or buckwheat order, the onion order, and the natural grasses or forage and cereal grasses. All these families or orders are treated of at such greater length as their importance seemed to deserve, yet not so as to exhaust their whole economical history, as if

'Physiology at the Farm' were not a mere illustration of scientific principles in animal nutrition, but a dictionary of practical agriculture—an impression under which some otherwise friendly critics seem to labour. The authors of 'Physiology at the Farm' do not think it would have been advisable, as suggested by one critic, to omit the short notices they have given of "scakale, salsafy, artichokes, and Chinese skirret," for the sake of making room for such a dissertation on field-cabbage as belongs to a work on practical agriculture—field-cabbage, however, being by no means neglected to the extent alleged by him. It would have been to deviate from their plan, which was not to accumulate details on well-known articles of diet, but to illustrate, in the simplest manner possible, the physiological value of every known dietetic plant.

Some critics object to notices of the dietetic plants of distant countries. Surely the physiology of animal nutrition is not confined to this island; and where is the latitude under which agriculturists speaking the English tongue, and able to read 'Physiology at the Farm,' are not to be found? To have omitted any notice of the water-maize or *Victoria regia*, as some suggest, would have been a far greater oversight than to have been meagre of statistics (which some one blames much) in respect to the vast increase in the consumption of common maize or Indian corn, as an article of food for animals in Britain, since the repeal of the corn-laws. The *Victoria regia*, the most gigantic of the water-lilies, with leaves from four to six or seven feet in diameter, and flowers one foot across, affords abundance of nutritive seeds, and is found everywhere in the still waters all over the eastern parts of South America, in quarters where British agriculturists are settling in crowds. As the seeds of the water-maize or *Victoria regia* have a strong analogy with poppy-seeds, it would not be surprising if some of our critics

who count so securely on the *Victoria regia* being beyond the limits of the agricultural world, should be startled some morning ere long when called on to announce the arrival of an importation of Victoria cake for the feeding of British oxen.

The authors of 'Physiology at the Farm' did expect to escape the charge of using anything like ornament in their work. There are but two passages in the whole book not in rigid prose, and each of these contains an important physiological fact. Nevertheless one of these passages has incurred the stern displeasure of an otherwise, for the most part, friendly critic. The passage is :—

> "This is every cook's opinion :
> No savoury dish without an onion.
> But lest your kissing should be spoiled,
> Your onions must be throughly boiled;"

referring to the remarkable effect of boiling in destroying the acrimony of the onion.

Our critic calls this "a silly doggerel rhyme,"—one he scarcely cares to reproduce in his periodical. The authors of 'Physiology at the Farm' can bear these hard words, because they know that the lines, not to speak of their truth, were penned by Dean Swift, and are quoted by Samuel Johnson in his Dictionary, as an example of model English.

To return from this digression. The fault to be found with Dr Voelcker is merely that he does not sufficiently discriminate between propositions applicable solely to the fattening of stock from general propositions in the physiology of animal nutrition, the effect being to perplex his less initiated readers as to what he wishes to inculcate. Dr Frankland deviates farther from the common views; and, in particular, he does not admit that muscular energy is dependent on the disintegration of the muscular fibres concerned, or that there is in consequence a proportional development of urea in the excretions.

Dr Voelcker's real heresy, so to speak, will appear from one or two citations from his recent lecture at the Royal Agricultural Society: "If we inquire upon which of the various constituents the feeding value of the articles of food given to stock really depends—whether it is on the nitrogen, or the fat, or the sugar, or the starchy compounds—we shall arrive at the conclusion that their money value depends not so much on the amount of flesh-forming constituents, or, in other words, on the amount of nitrogen which the different kinds of food are shown by analysis to contain, as on the proportion of ready-made fat and substances capable of producing fat. As I mentioned just now, the food which is richest in what are commonly called flesh-producing constituents does not in reality produce most easily, or most abundantly, butcher's-meat. You must remember that in butcher's-meat we have invariably a mixture of lean muscle, fibre, and fat; and this mixture is much more readily produced from a fair proportion of albuminous matter in food, with an excess of starchy substances, or an excess of ready-made fat, than it is produced from food in which there is an excess of flesh-forming constituents—albumen, caseine, gluten, or any of the other flesh-constituting matters which, in the animal economy, answer the same purpose. It is well to bear in mind, then, that the food which is richest in nitrogenous, or what are called flesh-producing, matters, is not exactly that description of food which produces, at the lowest cost, or most readily, butcher's-meat." *

* Supplement to 'Bell's Weekly Messenger,' April 15, 1867.

Although the constant phrase used by farmers and butchers is, that the stock is put up to fatten, yet it is well understood by them that the larger the quantity of flesh acquired by an ox, or a sheep, or a pig when put up to fatten, the animal becomes the heavier, and is thereby of greater value. If flesh can be accumulated on the frame, experience confirms that a sufficiency of fat will be produced in the carcass, so as to give it the quality of good butcher's-meat. Hence oxen, sheep, and pigs which exhibit a large propor-

This heresy of Dr Voelcker's, though very perplexing to those less familiar with the physiology of animal nutrition, is a heresy rather in appearance than in reality. He does not repudiate the distinction between flesh-forming substances and fat-producers; for he acknowledges the former to be nitrogenous, the latter to be non-nitrogenous substances. He does not believe that fat, as food, can produce flesh; but he believes it to be possible, by a too liberal allowance of flesh-producing substance, to render an ox or a sheep too active, and its flesh too dense and tough, to make good butcher's-meat, at the same time that an extra cost in money has been bestowed thereon. He says little more here than what would be equivalent in human physiology to saying that a man should not be fed too largely on butcher's-meat, because that is not only a more costly diet, but one less conducive to his health, than a diet including a considerable allowance of farinaceous food would be.

In 'Physiology at the Farm,' under the head of "Plethora," this subject is discussed in a theoretical point of view. "When nutrition," the authors say, "goes on vigorously, and an animal is freely exercised within the limits of its strength, amidst circumstances conducive to health and activity, the lines of the body are sharp and angular without disposition to rotundity of parts, the pulse of any considerable artery is full, strong, and swelling, the contraction of the muscles of locomotion is steadily energetic, the veins are full and tense, the secretions are everywhere abundant, and there is a boundless tendency to active movement. Here the due balance is preserved between the proportions of blood which belong respectively to the aortic system and to the system of the *venæ cavæ*. When, however, circum-

tion of flesh are more esteemed by the butcher than when they display huge accumulations of fat, such as are to be seen on animals at the Christmas shows of fat stock.—H. Stephens.

stances arise, the tendency of which is to weaken the force of the circulation of the blood, a change appears to take place in the distribution of the blood, the veins appropriating to themselves a larger proportion than naturally belongs to them. Nutrition may still go on freely, and the mass of blood be even greater than under the state first described. Excretion becomes diminished, and the solids become relaxed by the presence everywhere of a larger proportion of fluid parts; and in particular, a larger amount of oil or fat accumulates in the tissue appropriated to that secretion, whence the former sharpness and angularity of the contour of the body gives place to a more or less complete smoothness and rotundity.

"Thus the kind of management as to diet and regimen which fits an animal like a horse for powerful and continued muscular exertion, is very different from that which prepares an animal like the ox for slaughter, by rendering the solids soft, tender, and free from toughness. The essential difference appears to be, that an arterial plethora or fulness of blood is to be cultivated in the case of the horse, while a venous plethora is to be promoted in that of the ox." *

The nitrogen that is thrown off by an animal body in the excretions, as in those of the bowels and urinary organs, is the product of the disintegration of the nitrogenised animal solids, or of the nitrogenised constituents of the blood, some portion of which last, though prepared for assimilation, may have become decomposed by the oxygen received in respiration before they have undergone that process—that is, before they have become incorporated with any nitrogenised living solids.

This, then, leads to the distinction which will often be found convenient between the disintegration of the products of sanguification—that is, of substances prepared for nourishment,

* P. 251, 252.

but not yet used for nourishment—and the disintegration of assimilated substances—that is, of substances which already constitute part and parcel of some living solid. It is apt to be forgotten that the work within the body required for sanguification is almost as great as that required for assimilation ; in a word, that sanguification is but one small step short of assimilation, and therefore that the drain on the living system differs but immaterially whether in like proportion the products of sanguification undergo disintegration, or those of assimilation are subjected to that process. That the products of sanguification do suffer disintegration is not at all doubtful ; one manifest case being that in which an excess of food has been employed, so that more blood forms, in a given time, than the wants of the system require ; and another being that in which, owing to excessive bodily exertion, the energy put forth needs to be sustained, even by the disintegration of the constituents of the blood. The disintegration of the constituents of the blood here referred to is not that of the non-nitrogenised constituents, such as are continually so decomposed for the maintenance of animal temperature, but that of the newly formed albumen and fibrine, ready, if need be, to renew the substance of the solids. According to the prevailing view, the energy given forth when the muscular solids undergo disintegration, is that which feeds muscular action. It may be premature, however, to attempt to pronounce how that energy is employed which must flow from the disintegration of the nitrogenised constituents of the blood.

Here, in short, a difficulty presents itself, which probably cannot yet be cleared up. It seems to be quite correct to say that the nitrogenised products of excretion thrown off by a living body are the result of the disintegration of the motive organs that have been concerned in the work performed in a given time ; but, then, to their amount may be

superadded the effect of the decomposition of products of sanguification that has occurred during the same period, so that, there being no settled means of distinguishing between these two elements of the total amount, the precise quantity of work done cannot be thus determined. It is not, however, improbable that ere long some method may be discovered by which a distinction between these two effects may be drawn. An experiment made by Messrs Lawes and Gilbert illustrates this subject. Two pigs were fed, the one with lentil-meal containing four per cent of nitrogen, the other with barley-meal, containing only two per cent of nitrogen ; and the conditions under which these pigs were kept being exactly alike, that fed on the lentil-meal passed by excretion twice as much nitrogen as that fed on the barley-meal, so that no measure of difference in work performed was afforded.*

As respects animals, however, that can be easily weighed, empirical formulæ may be determined to show what amount of flesh-formers, fat-producers, and mineral matter, corresponds to a definite amount of exertion, so long as the body retains exactly the same weight, any excess thrown off from the blood being thus rendered a constant quantity; and by experiments of this kind, a criterion will probably be found to render the discrimination of the different sources of the excreted matter easy. Without frequent experiments, how little progress can be expected in the special physiology of nutrition in the animals of the farm ! If in a growing animal the periodical increase of weight were ascertained, also the amount of nitrogenised food consumed in the same space of time ; moreover, the difference between the proportion of nitrogen in the excretions and in the food for the specified time ; the amount of nitrogen fixed in the system for that period would be ascertained. It is plain, then, that if

* 'Philosophical Magazine,' vol. xxxii. p. 62.

the animal were in the mean time exercised sufficiently to prevent any accumulation of fat, the increase in weight by the deposition of nitrogenised substance would correspond to the difference between the amount of nitrogen in the food and that in the excretions, so that any influence of the blood in such a case being always the same, that difference would indicate the quantity of nitrogenised tissue disintegrated in a like time when no growth was going on.

There can be no doubt that the living nitrogenised molecules, whether of the blood or of the muscular tissue, go on in a progressive state to a maturity in which a spontaneous decomposition takes place. This, like a great many similar subjects, still rests in much obscurity, nor is it likely to have any light thrown upon it till the whole subject of ferments, fermentation, and putrefaction, receives elucidation.

The following is the passage in Dr Voelcker's lecture before referred to, which the writer in the 'Field' regarded as at once exposing the error into which Messrs Seller and Stephens had fallen, as he thought, by valuing foods in proportion to the quantity of nitrogenised matter they contain : "Some very accurate experiments have lately been instituted on the Continent, with a view of ascertaining how much of the nitrogenous constituents of food pass through the animal. For many years we have known that by far the largest proportion of nitrogenous matter passes through the animal, and is recovered in the dung. The loss of nitrogen which the food sustains in passing through the body has been variously estimated. By some it is stated to amount to one-tenth, and by others to one-fifth, of the total amount of nitrogen in the food. Recent experiments, however, seem to point out that the loss in nitrogen is not so great ; that probably not more than one-sixteenth, if so much, is lost when the food passes through the animal. Of course, in young stock a little of the nitrogenous food is required for

the building up of the muscle; but even in this case the total amount of nitrogen which is recovered from the food in the dung is very great in proportion to what is assimilated by the body, or may be supposed to be lost." *

This passage would have the effect ascribed to it by the writer in the 'Field'—namely, that of proving Messrs Seller and Stephens to be in error when they adopted Messrs Lawes and Gilbert's recommendation as to the quantity of nitrogenised food required for a rapidly fattening ox—only on the assumption that the animal solids could be repaired and augmented by the use of non-nitrogenised foods. Such an assumption, we are sure, could not obtain the concurrence of Dr Voelcker, therefore the writer's argument, as professing to be borrowed from that eminent chemist, at once falls to the ground.

The statement itself, however, does not at first sight seem distinguished by that clearness which usually marks Dr Voelcker's sentiments. Nitrogenised food may be regarded as represented by proteine, a compound consisting of 216 parts carbon, 27 parts hydrogen, 56 parts nitrogen, and 96 parts oxygen; but the renewal or augmentation of an animal solid, such as a muscle, is to be considered also as a deposition of proteine. If a muscle wastes, it wastes by the disintegration of proteine, and therefore what is requisite for its repair is the deposition of new proteine, which new proteine can only come from nitrogenised food. The disintegrated proteine of the muscle passes, by the help of the oxygen received in respiration, into new compounds, carbonic acid, water, and urea; the whole of its elements are so disposed of; there is nothing retained in the system: the whole of the nitrogen may not be discovered in the excretions, but what passes off by undiscovered channels is nevertheless lost to the system. The

* 'The Field,' April 27, 1867.

gelatigenous solids must, in the mean time, be left out of view, but their waste is not rapid. In 60 grains of urea there are 12 grains carbon, 4 hydrogen, 28 nitrogen, and 16 oxygen; hence, for every 395 grains of proteine, disintegrated by 344 grains of oxygen received in respiration, there is produced urea to the extent of 120 grains, carbonic acid to that of 448 grains, and water to that of 171 grains. It is not true that any portion of the nitrogen of nitrogenised food is retained in the animal unless in the case where a solid, such as a muscle, is growing; in that case proteine is deposited to augment its bulk, while, on that occasion, no disintegration occurs. But when a muscle grows, the whole nitrogen of the proteine derived from the food remains fixed in that muscle. It becomes more and more of a mystery, as we reason in this manner, what was turning in Dr Voelcker's mind when he penned this passage. We begin to invoke the shade of Œdipus. We almost turn to the possibility of a parallel, so unlikely in the case of a man of science, to the "quandoque bonus dormitat Homerus," when it fortunately occurs to us that we are dwelling on a quotation made by the writer in the 'Field' from Dr Voelcker, and that this passage should be studied at its right place in juxtaposition with the adjacent parts of the lecture. Then, indeed, the light dawns upon us —the passage in question turns out to have no reference whatever to the fattening of oxen, but only to the encouragement afforded to the use of nitrogenised food in the feeding of stock, owing to the almost complete accumulation of the fertilising nitrogen, in the excretions fit for manure —that is to say, to the very small loss of that nitrogen by undiscovered channels in passing through the body.

Here, again, is another hint to Dr Voelcker to take the measure of his auditors before he determines how he is to address them; for the writer in the 'Field' plainly took

what he said in a sense exactly the opposite of what was intended.

It is the more surprising that the writer in the 'Field' has fallen into these mistakes, because in the rest of his observations on the part of the lecture referring to such manures as potash and phosphoric acid, and even ammonia, he speaks like a sensible practical agriculturist.

We take our leave, then, of Dr Voelcker, while we pronounce our opinion, in direct opposition to that of the writer in the 'Field,' that he is everywhere sound and consistent with the principles of animal physiology, though we think his sentiments might have been sometimes so far better guarded from perplexing or misleading the young and less initiated student of that physiology. We take our leave also of our critic in the 'Field,' trusting that he will not again charge the authors of 'Physiology at the Farm' with constructing formulæ for the feeding of stock on obsolete data, when they rely on the most enlightened experiments of the time, such as those of Messrs Lawes and Gilbert.

We have still a word for the views supported with so much determination by Dr Frankland. There is one set of facts with which Dr Frankland's ideas seem to be utterly incompatible; and, to save time, we shall at present confine our attention chiefly to that incompatibility.

Is it, or is it not, an established fact that an animal dies of starvation after no long time, if fed exclusively on non-nitrogenised aliment? If it be a fact, why does the energy necessary for the support of life fail, if the combustion of non-nitrogenised aliment within the body be sufficient to produce that energy on which muscular contraction is dependent?

Here is the state of the case. The living system is in full force supplied sufficiently with non-nitrogenised aliment,

and its functions—circulation, respiration, animal heat, and all the rest—going on vigorously for a time. By-and-by its activity begins to fail, and in no long time it finally perishes, nothing being withdrawn of those conditions under which at first it went on so prosperously. From the beginning, then, there was something wanting; but on inquiry there is found to have been nothing deficient of the circumstances under which health usually prospers, except the denial of nitrogenised aliment. The inference is inevitable, that the defect of nitrogenised aliment is the cause of the failure in the energy of the living system. If it be said that the energy exercised in the living system cannot exceed what is due to the amount of carbonic acid produced by the slow combustion of the oxygen received in respiration with the carbon of the solids thereby disintegrated, it is to be remembered that carbon does not spontaneously combine with oxygen at such a temperature as belongs to the bodies of mammals, at least at all rapidly, and therefore that there must be some condition superadded to the mere presence of carbon and oxygen to enable them to combine so freely at that temperature, and give forth the energy due to their combination. But it will not be easy to find, by any amount of research, any other condition under which such a combination can be effected at that low temperature, but the combination of the elements of nitrogenised bodies with the oxygen of respiration—a combination which takes place at the animal temperature even out of the living body.

Saccharine matter, no doubt, undergoes fermentation, producing carbonic acid and heat at a somewhat lower temperature than belongs to the animal body; but even that fermentation does not arise without the presence of a nitrogenised ferment; whence it may be inferred that, when nitrogenised aliment is withheld, even that temperature which results from the combustion of non-nitrogenised matter with

the oxygen received in respiration ceases to be produced. This, at least, is a view of the subject that imperatively requires to be inquired into.

It appears that some of those who side with Dr Frankland think that the muscular system finally loses its substance and its energy by the loss sustained by friction; but the debris of the muscles produced by friction must be digestible, so that there should be no urgent need of other nitrogenised food. The possibility of effete matters serving for nourishment is debated, and a negative pronounced, at pages 76 and 77 of 'Physiology at the Farm.'

The effect of friction in living bodies doubtless requires more attention than has hitherto been bestowed thereon. If the parts of the living solids concerned in motion be not chemically decomposed at the moment, some of their particles must be detached by friction; but the effect of friction cannot be more than a mechanical abrasion, and not at all a real chemical death of such parts, or a decomposition into actual mineral matter. Whatever is separated by friction from a living solid must still possess an organic constitution—that is to say, a constitution, like that of organic food, derived from the lifeless but not yet decomposed parts of vegetables and animals. Such parts of the contractile living solids as are detached by friction must be capable of a new digestion and assimilation, so as in a certain measure to supply the deficiency of fresh nitrogenised food.

Thus Dr Frankland's view becomes untenable, unless the proposition can be overthrown that animals perish when confined for a time to non-nitrogenised aliment. This proposition should be his first point of attack; but the more that proposition is examined, the more certain does it become.